MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2015/2016

EEL1196 – INSTRUMENTATION AND MEASUREMENT TECHNIQUES

(All sections / Groups)

5 MARCH 2016
2.30 p.m. – 4.30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This Question paper consists of 6 pages including cover page with 4 Questions only.

2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please print all your answers in the Answer Booklet provided.

Question 1

(a) What is the function of a signal manipulating element in a generalized measurement system? Give an example of a signal manipulating element and describe its function. [4 marks]

(b) The cutoff frequency, f_c, for a low pass filter is given by the following equation:

$$f_C = \frac{1}{2\pi RC}$$

The components used in the design of the filter are: $C = 0.02\ \mu F \pm 2.6\%$ and $R = 1.5\ k\Omega \pm 0.5\%$. Calculate the cutoff frequency, f_c, and its relative limiting error in percentage form. [7 marks]

(c) According to Planck's quantum hypothesis, the energy, E, of oscillations of atoms within molecules is given by the following relation:

$$E = \frac{hc}{\lambda}$$

where h is Planck's constant, c is the speed of light and λ is the wavelength. Using the equation above, express the dimensions of h in base units. [4 marks]

(d) A circuit is connected as shown in **Figure Q1(d)** below:

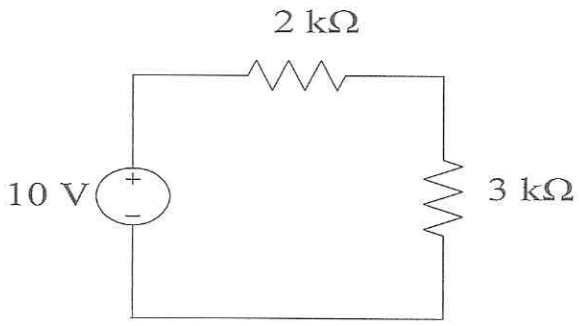

Figure Q1(d)

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(i) Determine the true value of current flowing in the circuit. [1 mark]

(ii) If an ammeter with an internal resistance of 500 Ω is used to measure the current in the circuit, what is the measured current value? [2 marks]

(iii) Calculate the percentage error and percentage accuracy as a result of the internal resistance of the ammeter. What type of error is this? [3 marks]

(iv) If an accuracy of 95% is required for the measured current value, what should the internal resistance of the ammeter be? [3 marks]

(v) Suggest one way the error can be minimized. [1 mark]

Question 2

(a) A 100 mA DC ammeter has an internal structure shown in **Figure Q2(a)** below. Given that the PMMC has an internal resistance of 20 Ω and gives a 100-degree full scale deflection when carrying a current of 10 mA.

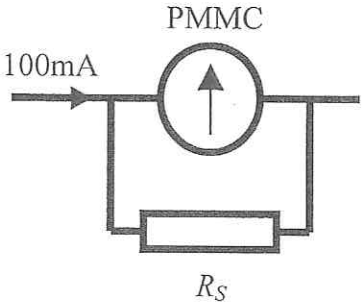

Figure Q2(a)

(i) Find out the value of resistance, R_S. [3 marks]

(ii) Calculate the deflecting torque produced at full scale deflection if it has a spring constant, $k = 11 \times 10^{-6}$ Nm/rad. [2 marks]

(iii) Explain briefly why the existence of damping torque is important in any indicating instrument. State **TWO** methods to produce damping torque. [2+2 marks]

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(b) A moving iron instrument has an inductance of $L = (2\theta^2 + 2\theta - 5)$ μH, where θ is the deflection angle in radians from zero position. Given that the deflecting torque, $T_d = \frac{1}{2} I^2 \frac{dL}{d\theta}$, estimate the amount of current that will cause a deflection of 0.65 radian if it is a gravity-controlled type instrument with constant, $k = 5 \times 10^{-6}$ Nm.

[4 marks]

(c) A ballistic galvanometer is used to measure the magnetic flux density, B, of a ring sample using the reversal method. As a primary current of 12 A is reversed, the galvanometer gives a throw of 250 scale divisions. The galvanometer is connected to a secondary winding with 150 turns and the total resistance of the secondary circuit is 1.5 kΩ. The ring sample has a mean diameter of 5 cm and cross sectional area of 2.5 cm^2. If the galvanometer constant is 2 μC per scale division and the primary coil has 100 turns, determine:

(i) the flux density in the sample, B, [3 marks]

(ii) the applied magnetizing force, H, and [4 marks]

(iii) the relative permeability of the sample, μ_r. [2 marks]

(iv) If the galvanometer is replaced with a fluxmeter with a constant of 1.2×10^{-4} Weber-turns per unit deflection, determine the expected deflection of the fluxmeter, θ (in scale divisions). [3 marks]

Given the following constant: Permeability of free space, $\mu_0 = 4\pi \times 10^{-7}$ H/m.

Continued...

Question 3

(a) Telephone companies use the Wheatstone bridge extensively to locate faults in cables. State the 3 differences between the Murray Loop test and the Varley Loop test methods. [6 marks]

(b) A Maxwell Induction Bridge can be used for measurement of medium inductances and can be arranged to produce results with high precision. For the circuit provided below in **Figure Q3(b)**, if given that $R_1 = 400\ \Omega$, $R_3 = 2\ k\Omega$, $R_4 = 1\ k\Omega$ and $L_1 = 500$ mH:

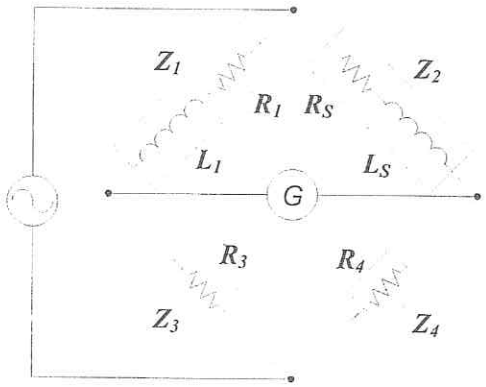

Figure Q3(b)

(i) When the bridge is under balanced condition, determine the values of the unknown resistance, R_S, and inductance, L_S. [8 marks]

(ii) Determine the quality factor of the coil, Z_2, if the supply frequency is 2000 rad/s. [5 marks]

(iii) If the circuit is excited by a 2 V, 500 Hz oscillator, find the unbalanced voltage, if $L_S = 300$ mH. [6 marks]

Continued...

Question 4

(a) A balanced delta-connected load of (2+j5) Ω per phase is connected to a balanced 3-phase 200 V supply. The two wattmeters method is used to measure the total power consumed by the loads.

(i) Calculate the power factor, phase voltage and line current. [6 marks]

(ii) Estimate the readings for both wattmeters. [3 marks]

(iii) State **THREE** benefits of using an electronic wattmeter. [3 marks]

(b) With the aid of a diagram, briefly explain the working principle of a resistive position transducer (potentiometer). State 2 disadvantages of this transducer.

[4 + 2 marks]

(c) A resistive position transducer is used to monitor moving objects with the arrangement shown in **Figure Q4(c).** It is given that the voltage V_T = 6V, the resistance $R_1 + R_2 = R_3 + R_4$ = 10 kΩ and the shaft stroke = 7 inches. The initial position to be used as a reference point is such that $R_1 = R_2$ (the shaft is at midstroke). Before the measurement is done, the potentiometer R_3R_4 is adjusted so that the bridge is balanced ($V_E = 0$). When an object being monitored moved, it caused the wiper to move 2 inches towards A. Determine the new value for V_E.

[5 marks]

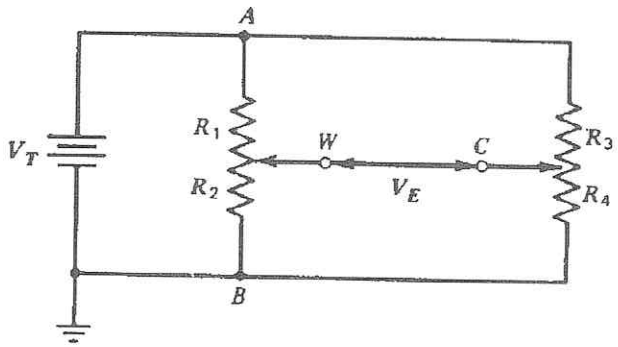

Figure Q4(c)

(d) Linear Variable Differential Transformer (LVDT) is another device used to measure position or displacement. State two advantages of LVDT. [2 marks]

End of paper.